

A METAPOPOPULATION MODEL WITH LOCAL COMPETITIONS

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ABSTRACT. A metapopulation model with explicit local dynamics is studied. Unlike many patch-based metapopulation models which assume that the local population within each patch is at its equilibrium, our model incorporates population changes in local patches that interact with metapopulation dynamics. The model keeps track of the fractions of patches that have species 1 only, species 2 only, or both species. For patches with both species, the Lotka-Volterra type of competition is assumed. It is shown that when the local dynamics is coupled with the metapopulation dynamics the model outcomes can be very different comparing with metapopulation models that do not explicitly include local population dynamics. The analysis of the coupled system is carried out by using techniques in singular perturbation theory.

1. Introduction. In 1969, Levins considered the following single-species metapopulation model which assumes that changes in patch occupancy are functions solely of colonization rates of empty patches (c) and extinction rates of occupied patches (e):

$$\frac{dp}{dt} = cp(1 - p) - ep, \quad (1)$$

where p denotes the proportion of the occupied patches. This simple model captures the basic fact that species persistence depends on the balance between local extinction and recolonization. Based on this framework, metapopulation models have been used extensively to analyze the dynamics of species in fragmented landscapes and to understand the potential implication of habitat fragmentation. For example, [1, 7, 9, 10, 11, 22] studied the dynamics of single species in a network of habitat fragments while [4, 15, 16, 17, 20] investigated the interaction of multispecies. Just like model (1), all these works fail to account for the local population dynamics. The colonization rate c in model (1) is directly related to migration rates. For species with high emigration rates, the lack of incorporation of local dynamics may lead to biased predictions (see, for example, [8]).

2000 *Mathematics Subject Classification.* Primary: 92B05; Secondary: 34A34.

Key words and phrases. Metapopulation models; Local population dynamics; Competition; Coexistence.

This research is supported in part by the NSF grants DMS-0719783 to DX and DMS-0719697 to ZF.